REMARKS

The subject invention relates to optically pumped semiconductor (OPS) lasers. In these devices, a semiconductor chip is formed with a multi-quantum well gain medium (12) and an attached resonator mirror (14). An external mirror (not shown in the drawings) defines the resonator. The surface of the gain medium is optically pumped to generate laser light.

Continuing efforts are being made to increase the output power of these OPS lasers. As the power levels increase, it becomes more important to remove heat from the gain structure. In the past, it has been known to bond a copper heat sink to the OPS chip to remove heat. To improve heat flow, it has also been known to adhesively bond a diamond heat spreader between the OPS chip and the copper heat sink. Adhesive or solder bonding is simple and inexpensive but has certain problems. First, the solder is not particularly thermally conductive and thus restricts the heat flow from the chip to the heat sink. Further, when heated, the solder can produce stresses between the bonded elements that can alter optical properties and even result in cracks in the chip.

To overcome these problems, applicants began investigating bonding the chip to the heat sink without adhesive. The solution to the problem was to use a contact bond. Such a bond is achieved if two extremely clean, extremely smooth surfaces are brought together under pressure. If the surfaces are smooth enough, atomic forces (van der Waal forces) from one surface attract the other surface making an extremely strong, virtually unbreakable bond. Preferably, the elements are heated to improve the shear strength of the bond.

In the current Office Action, as well as the previous Office Action, the Examiner rejected the main claims based on a combination of the commonly owned patent to Salokatve (6,327,293) in view to Bewley (6,448,642). In the response to the last Office Action, applicants pointed out how Bewley describes an arrangement wherein the connection between the chip and the heat sink is not a permanent or fixed connection. In the patent, Bewley states "The bond is in no way permanent. When the pressure is removed, the materials separate without any damage to either surface." In this regard, applicants submitted a 1999 Bewley article which showed how Bewley's clamping arrangement was achieved by tightening a "chisel pointed screw."

In order to overcome this prior art, applicants amended the independent claims to recite that the heat conducting element was pressure contact bonded "in a fixed manner" without adhesive to the OPS chip. In the Office Action, the Examiner rejected the claims under section

112 for failing to meet the written description requirement with respect to the added limitation. The Examiner then rejected the claims, repeating his prior rejection without consideration of the added subject matter which he felt was improperly added to the claims. Applicants respectfully traverse the Examiner's rejection.

When considering the written description requirement, it is well settled that words added to a claim do not have to appear expressly (*in haec verba*) in the specification. Rather, it is only required that the overall teachings of the specification are sufficient for one skilled in the art to understand that applicant's bond was intended to be permanent or fixed. The burden is on the Examiner to demonstrate a lack of written description (MPEP 2163.04). As discussed below, when the specification is read as a whole, one skilled in the art would unquestionably understand that the written description requirement has been satisfied.

As a starting point, the specification repeatedly uses the words "bond," "bonded," "contact bonded" and "optical contact bonded." Virtually any dictionary definition of "bonded" includes the concept of some form of permanence of connection. For example, the Oxford online dictionary defines "bonded" as "joined securely together, especially by an adhesive, heat process, or pressure." One skilled in the art confronted with these various terms would in the first instance assume that the connection was fixed. Applicants note that Bewley also uses the term bonded. However, Bewley expressly states that his bond was not permanent. Bewley understood that without that disclaimer, one skilled in the art might assume his bond was permanent, when in fact it was not.

Although applicants believe the use of the terms such as bonded, contact bonded and optical contact bond are alone sufficient to support the proposed amendment to the claims, there is much more in the specification that would remove any doubt about this conclusion.

The primary teaching about the nature of this bond is set forth in the specification at page 10, line 13, reproduced below with emphasis added:

> It is preferable when optically contacting a diamond (CVD, natural or type IIa-synthetic) or any other highly thermally conductive heat spreader material to a semiconductor epitaxial layer structure, that the surfaces of both the layer structure and the heat spreader be **very clean and very flat, preferably flatter than 0.2 waves at 635 nm.** Standard optical contacting methods are used, well known in the industry. Regarding cleanliness, it is preferable that contacting be carried out on a class 100 clean bench and that surfaces be finally cleaned with an organic solvent such as acetone, methanol and iso-propanol.

> Once the heat spreader and the semiconductor chip are clean, one edge of the semiconductor chip is pressed against the heat spreader and the two surfaces are brought into contact with pressure. **This usually requires multiple attempts of recleaning and contacting**. Once a full surface optical contact has been made, the contacted, assembled structure **is annealed at temperatures between 100°C and 350°C.** Then the substrate supporting the semiconductor epitaxial layer structure is etched away, leaving the finished optical semiconductor device optically contacted to the heat spreader material. This assembled structure is then soldered to a copper heat sink. This optical contact method can be done at a single device level or, alternatively, at a wafer level (multiple semiconductor devices on a single substrate or wafer) for high volume assembly. If contacted at a wafer level **the contacted structures on the wafer are diced into individual chips** after contacting and etching, and then each individual chip is soldered to a heat sink.

The first additional indication that this bond is permanent or fixed is the specific requirement that surface roughness be less than 0.2 waves at 635nm. This extreme level of flatness is required for a bond that is created when two elements are to be brought together so closely that the atomic bonding forces (van der Waal forces) come into play.

Second, the specification describes that to get a successful bond "multiple attempts of recleaning and contacting" are usually required. Regarding this disclosure, if the bond was not fixed, there would be no need to repeat these steps a number of times. In addition, the reference to recleaning recognizes that any particulates that were present would prevent the surfaces to be bonded from coming into sufficiently close contact to complete the bond.

The specification also teaches that the elements should be annealed at high temperature. As noted above, annealing improves the shear strength of the bond. If the bond were not permanent, there would be no need to anneal the bond.

Finally, the above-cited paragraph discusses how the contact bond approach might be used to bond chips and heat sinks on the wafer scale (multiple OPS chips, multiple heat sinks). In such a case, after the bonding is completed, the contacted structures are "diced" into individual chips. Dicing or chopping up a wafer into chips is a relatively intense mechanical procedure. Unless the bond between the chip and the heat sink is very strong, the wafer could not be diced without that bond breaking.

It should also be noted that the specification at page 5, line 4 compares the bond to "an 'optical contact' that is sometimes used in the optical industry to form an adhesive-free bond between smooth, flat components of optically transparent, solid materials such as glass or fused

silica." Again, one skilled in the art would understand that an optical contact bond was fixed or permanent.

Based on the above, it is respectfully submitted that the disclosures in the subject specification are more than adequate to support the narrowing of the claims to specifically define the contact bond as being in a fixed manner. Since Bewley fails to teach such a bond, the primary rejection must be withdrawn.

In the Office action, the Examiner also relied on patents to Zayhowski, Raymond and Pinneo. These secondary references are discussed in detail in applicants' previous response. In summary, none of these secondary references can overcome the deficiencies of the primary references in anticipating or rendering obvious applicants' invention as defined by the amended claims.

Based on the above, it is respectfully submitted that all of the claims remaining in the application define patentable subject matter and allowance thereof is respectfully requested.

Respectfully submitted,

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